Poly-Si Seed Layer Prepared by Aluminum-Induced Crystallization

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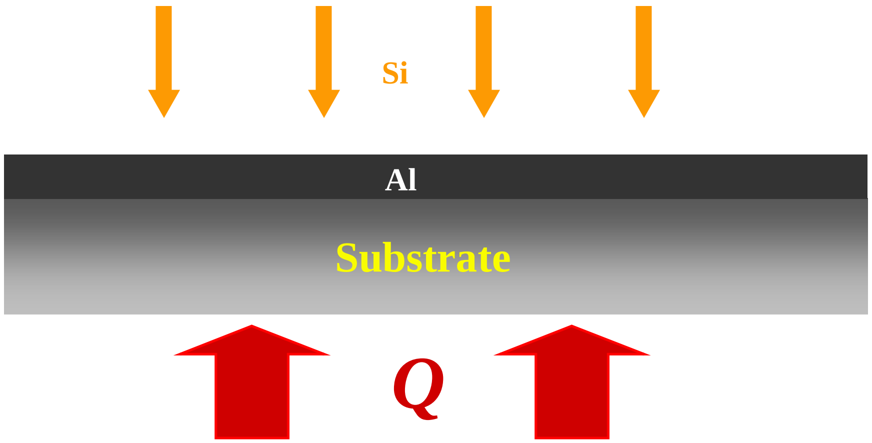
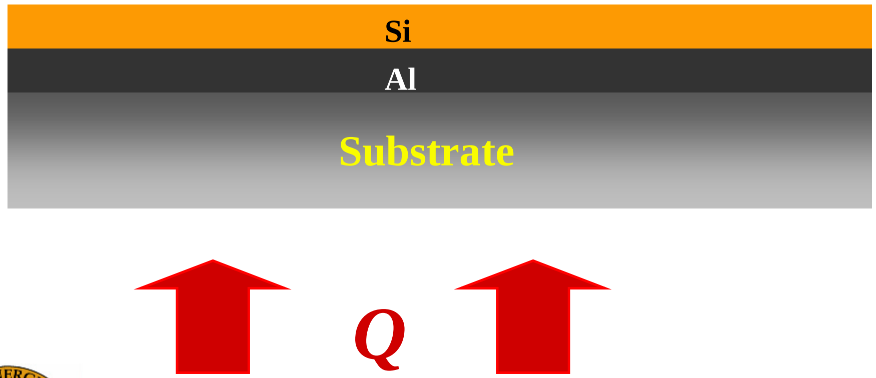
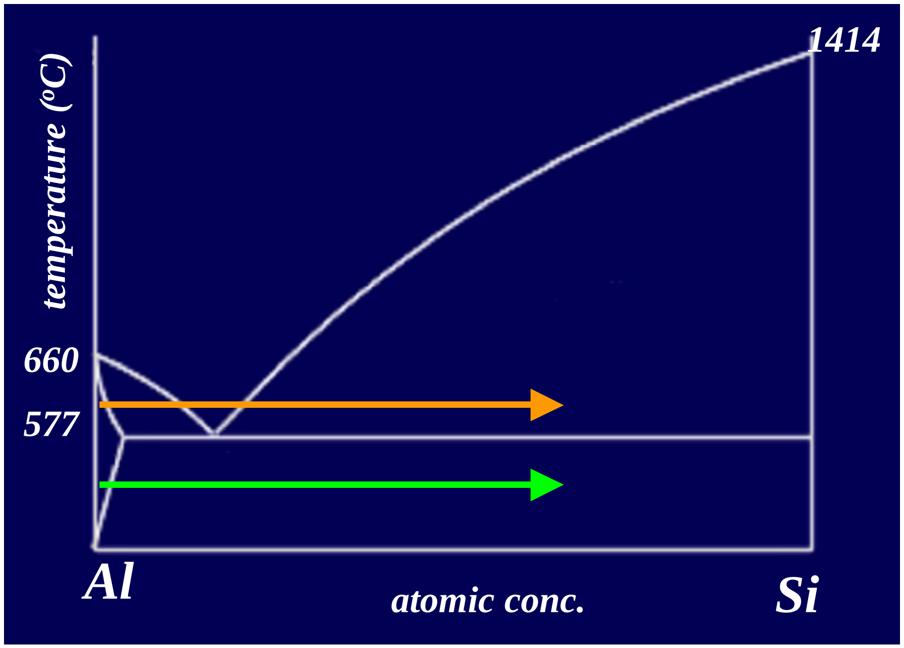
Metal-Induced Crystallization (MIC) : Experimental Approach

Aluminum-induced crystallization during deposition



Conventional aluminum-induced crystallization

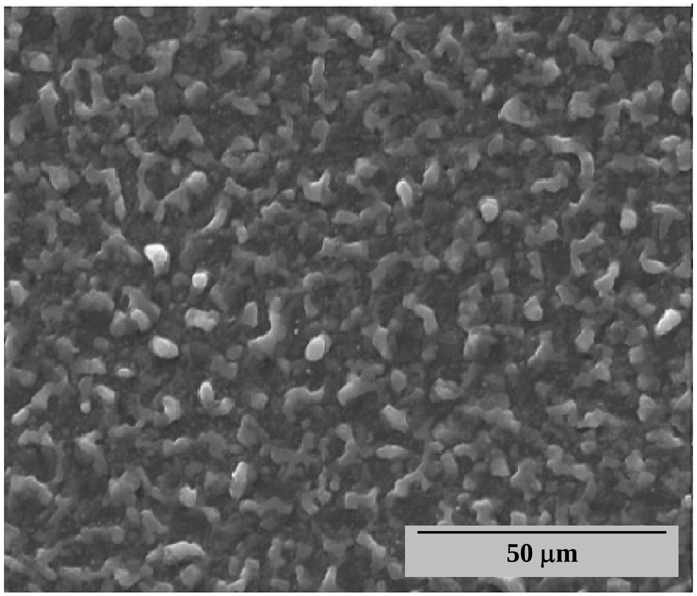




- **Below eutectic**
- **Above eutectic**

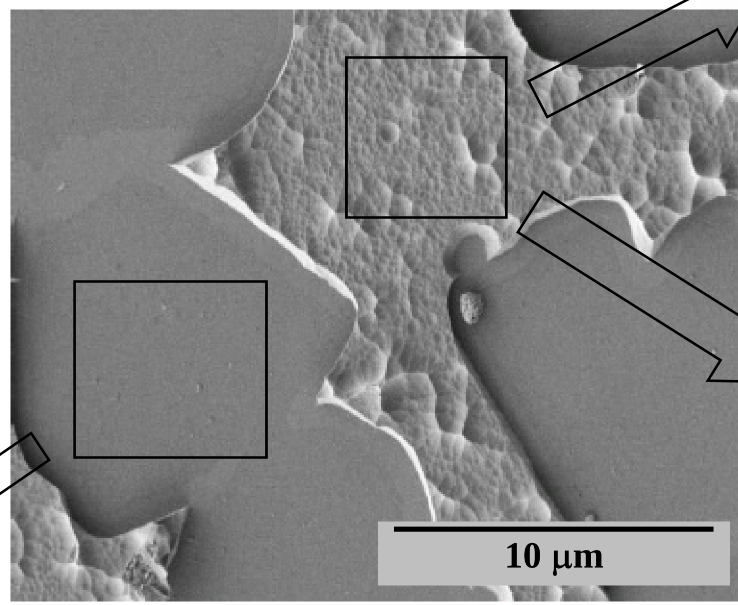
Substrate : Corning 7059 Glass
Al layer : E-beam (100-1000 nm)
Si layer : E-beam, PECVD, HWCVD (100 nm – 5 µm)

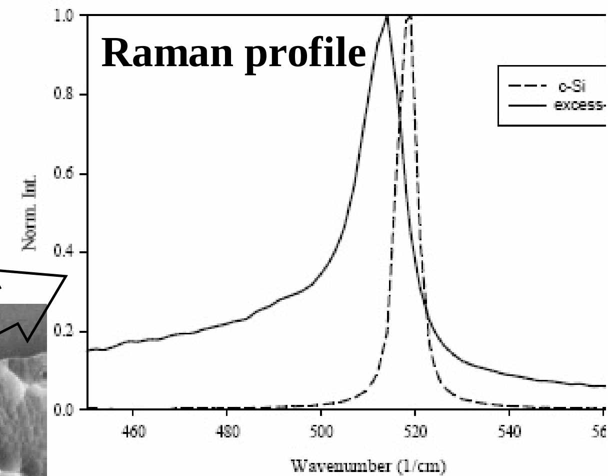
MIC During Deposition Below Eutectic Temperature

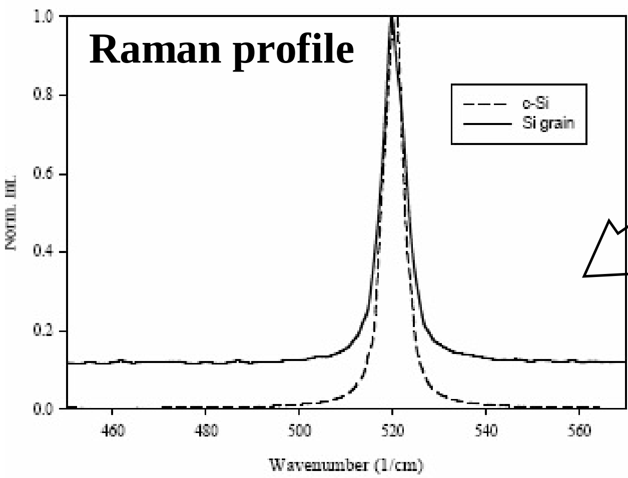


SEM images

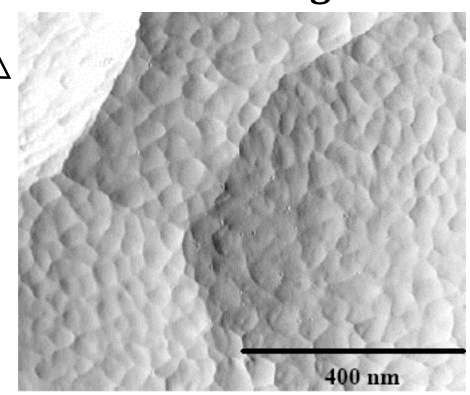
glass/500 nm Al/600 nm Si





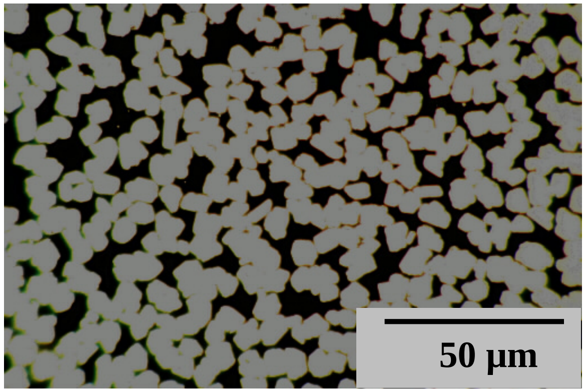


AFM image

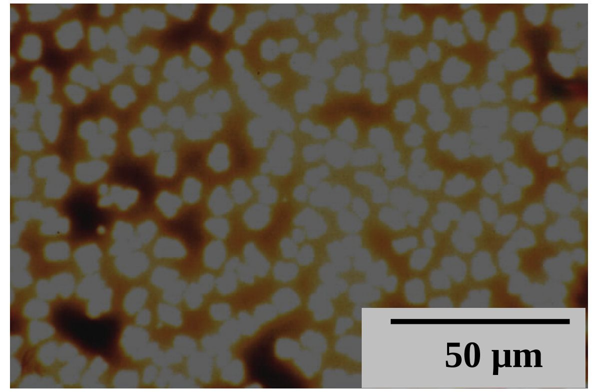


MIC During Deposition Below Eutectic Temperature

Transmission optical micrographs suggest columnar growth

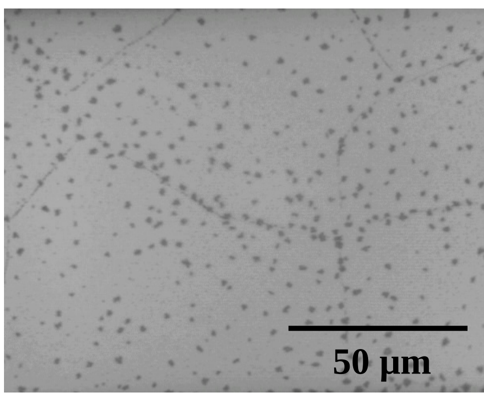


through glass substrate

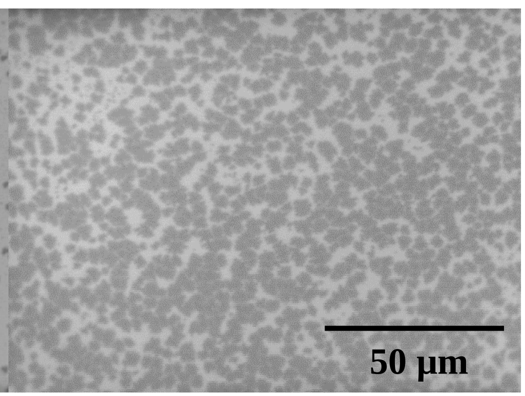


from top surface

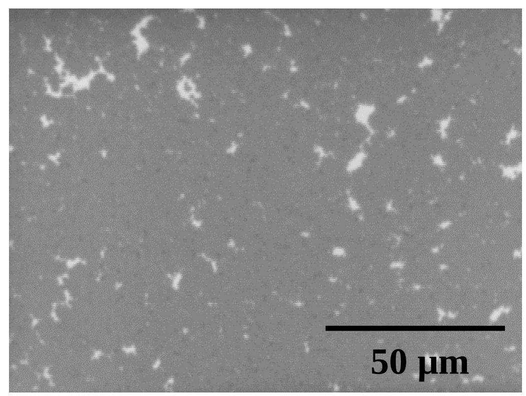
Optical microscopy images taken through glass substrate



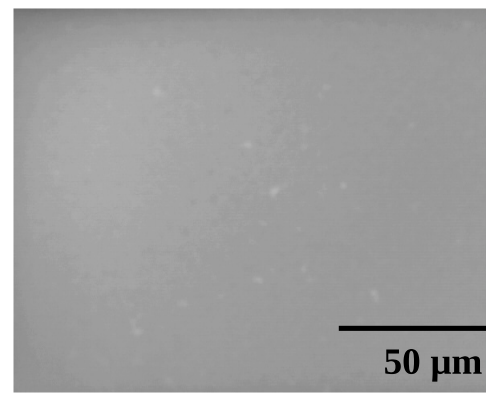
Si/Al = 0.5
t_{Al} =1000 nm



Si/Al = 1.0
t_{Al} =1000 nm



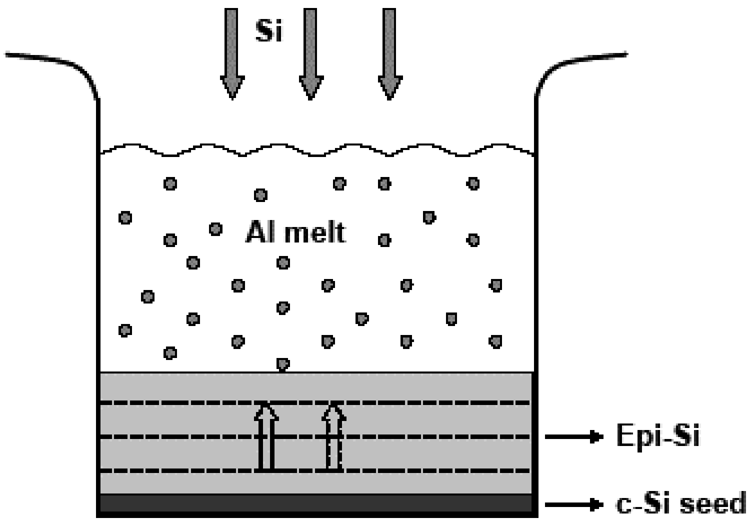
Si/Al = 1.0
t_{Al} =500 nm



Si/Al = 1.2
t_{Al} =500 nm

MIC During Deposition Above Eutectic Temperature

Vapor Liquid Solid (VLS) Growth

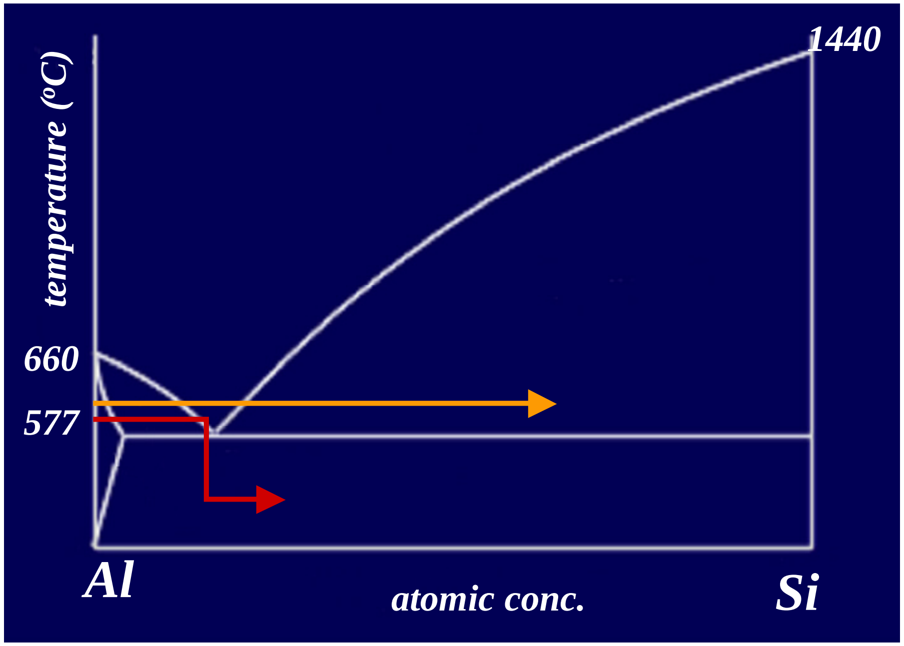


- Si atoms delivered to liquid phase from vapor
- Liquid medium enables fast diffusion of Si
- Si atoms are attached to crystalline phase

Experimental parameters

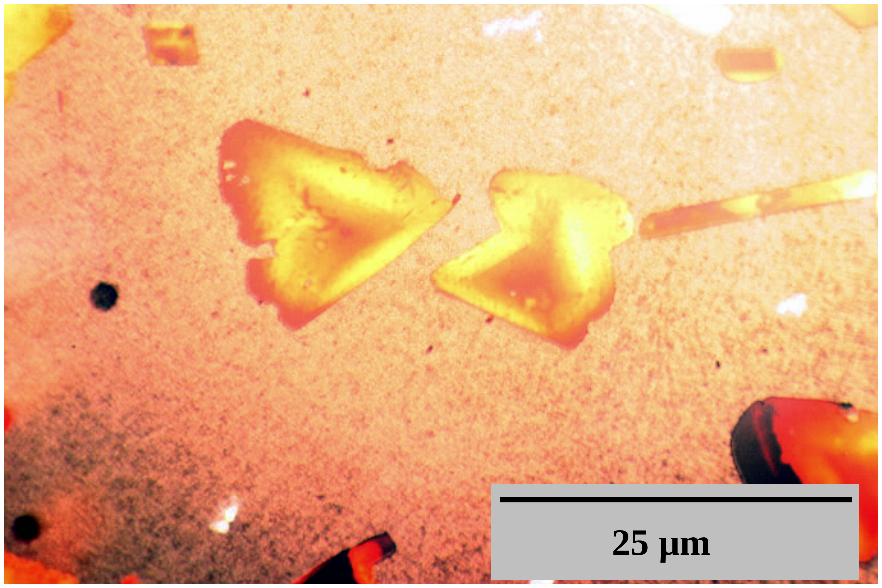
• Aluminum Layer Thickness : 100 nm - 1 μm
Aluminum deposited by E-beam

• Silicon Layer Thickness : 100 nm - 5 μm
Silicon deposited by HWCVD

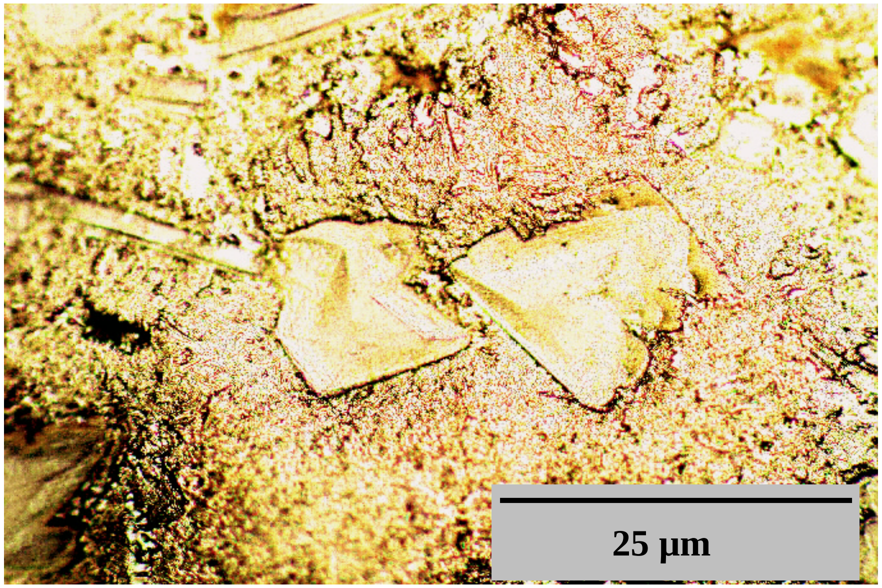


MIC During Deposition Above Eutectic Temperature

Optical micrographs in transmission mode

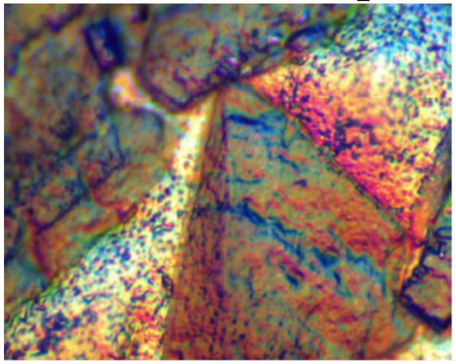


from bottom



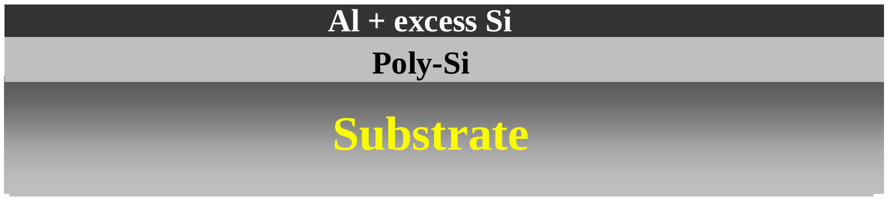
from top

- **Columnar grains showing three-fold symmetry**
- **Strong (111) orientation by XRD**
- **Thickness of the grains as big as 6 µm (for 500 nm thick Si) →**
- **No continuous Si films on glass above eutectic temperature**



Conventional MIC

Conventional aluminum-induced crystallization



After Annealing

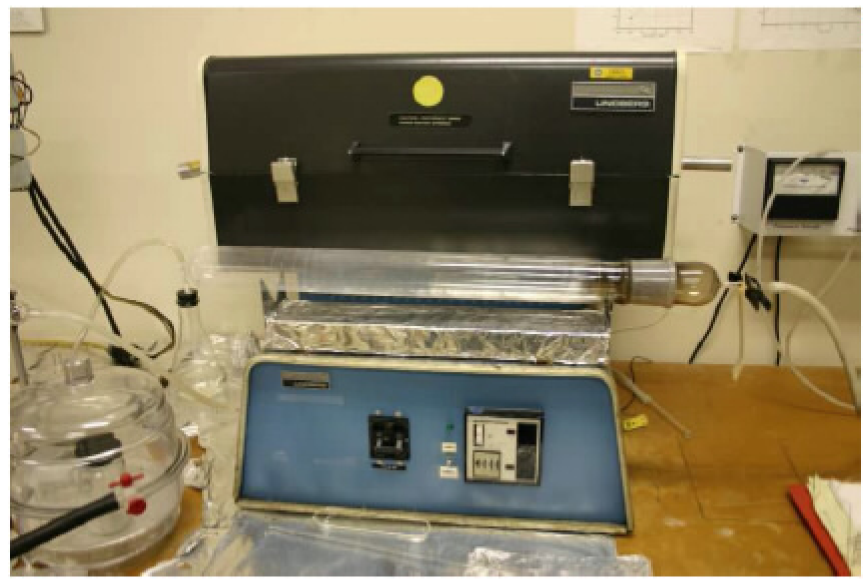
Annealing

Annealing Temperature : 430, 475, and 540 ºC
Annealing Time : 15 min. – 10 hrs.
Annealing Atmosphere : 30 sccm Ar

Deposition Parameters

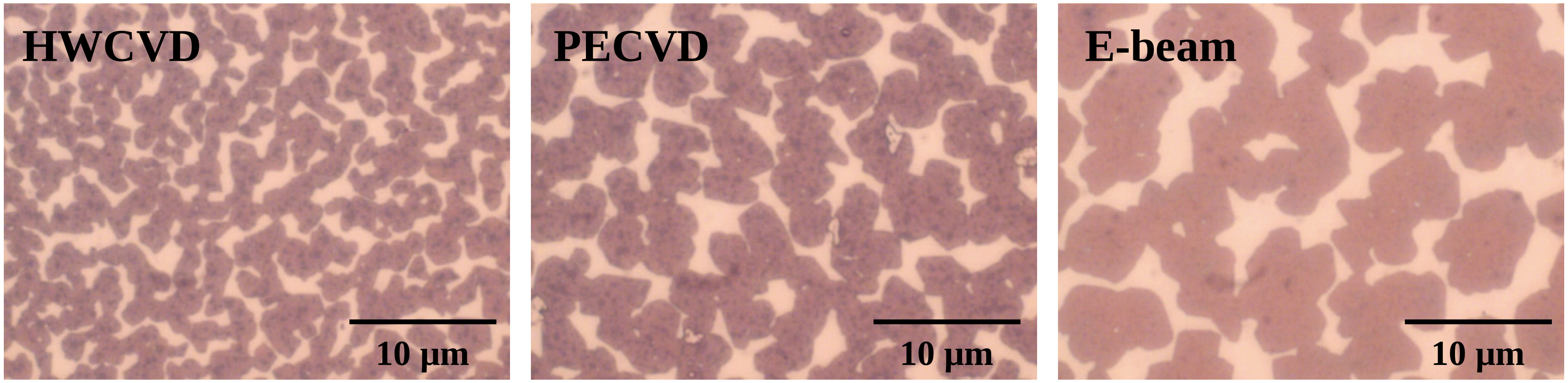
Aluminum Layer Thickness (t_{Al}) 100 nm - 1 µm
Aluminum deposited by E-beam

Silicon Layer Thickness (t_{Si}) : 100 nm - 5 µm
Silicon deposited by E-beam, PECVD, HWCVD



Conventional MIC

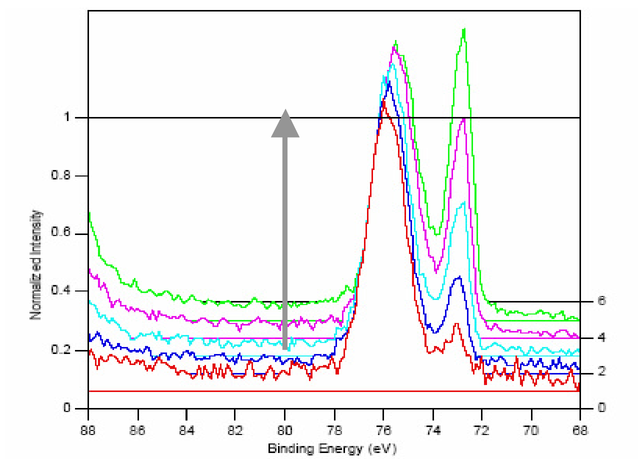
OM images during MIC process



- **Hydrogen seems to have a detrimental effect on grain size**
- **Atomic hydrogen in HWCVD etches off the oxide layer**

PS depth profile
250 nm Al on glass

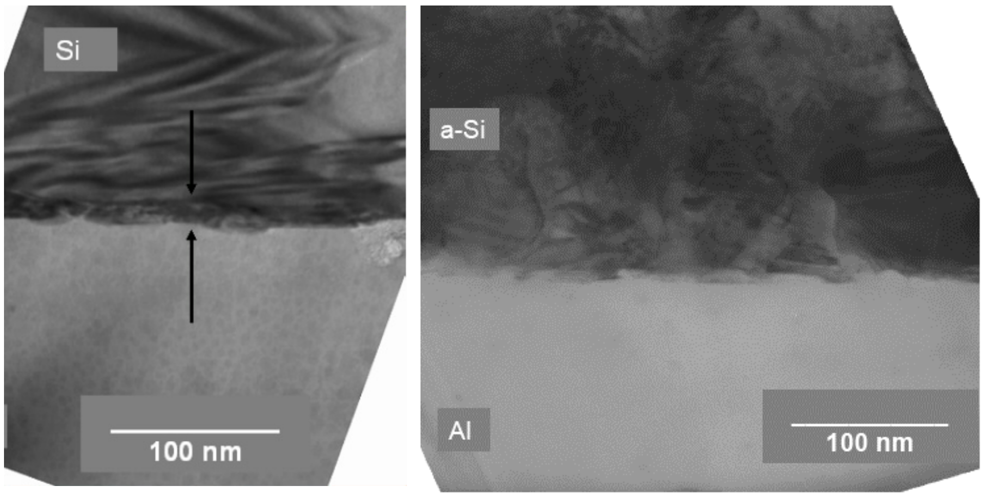
inding Energies
l-Al : 73.0 eV
l-O : 75.6 eV



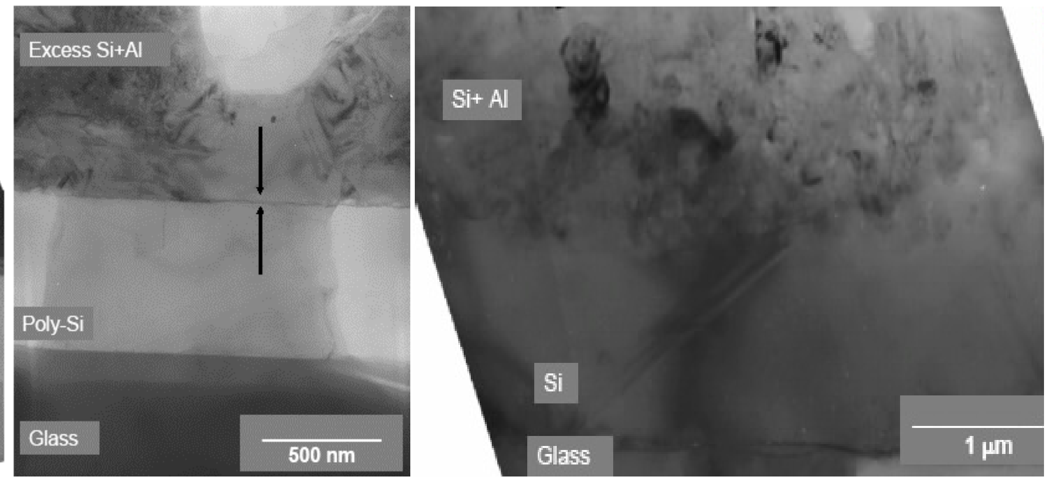
- **Shift to a lower energy as the depth increases → higher oxidation state on the surface**
- **Possible bilayer structure; Al_2O_3 and $Al(OH)_3$**

Interface Issues

TEM cross-section images before annealing



TEM cross-section images after annealing



- **The interface oxide layer is not homogeneous or continuous**
- **It allows material transport in each direction during crystallization**

- **The interface oxide layer does not change its position during crystallization**
- **Interface oxide layer is required for layer exchange process, not for crystallization**

Conclusions

<u>MIC during deposition below eutectic temperature</u>

For the first time continuous poly-Si films on glass substrates was prepared by aluminum-induced rystallization during deposition of Si using HW-CVD.

Continuous poly-Si films with a grain size / thickness ratio of 20 were obtained; 10 μm average grain size for 00 nm thick Si films.

The optimum Si/Al thickness ratio was found to be 1. Increasing Si/Al ratio did not improve the average rain size or the thickness of the poly-Si film.

The overall activation energy for crystallization and layer exchange process was determined to be 0.9 eV. he limiting factor is the material transport through the interfacial oxide layer.

<u>Conventional MIC below eutectic temperature</u>

The grain size is determined by three factors; the grain structure of Al layer, the nature of the interface xide, and crystallization temperature.

The interface oxide is crucial for layer exchange process but not required for crystallization. The oxide yer formed on Al films has a bilayer structure containing Al_2O_3 and $Al(OH)_3$.

The gas phase chemistry during deposition of Si important. Hydrogen seems to have a detrimental effect on rystallization process.